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Application of the RMA2 / RMA4 models to simulate pollution transport in a retention reservoir

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Range of presentation:

1. The aims of simulation
2. Dobczyce Lake
3. Model description
4. Methodology
5. Results of simulations
6. Summary and conclusion

The main aims of the simulations:

- Presenting RMA2/RMA4 models as a tool that supports analysis of dissolved pollution propagation
- Test simulations on the Dobczyce Lake

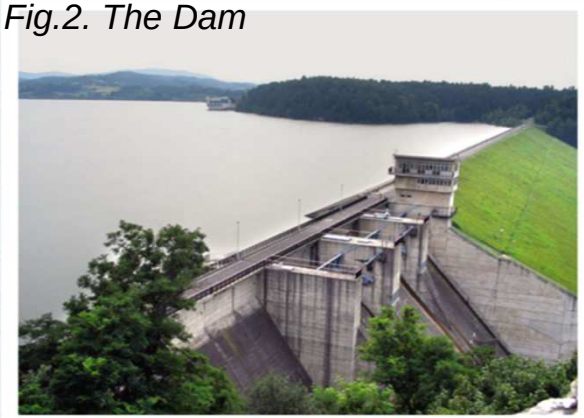
Characteristic of the Dobczyce Lake:

Location:

- Southern Poland
- Małopolskie province
- Dam on the 60th km of Raba river

Fig.1.Location of the Dobczyce Lake

Fig.2. The Dam



The functions of the reservoir:

- Source of the potable water for Cracow
- Flood protection
- Power generation
- Fish planting
- Landscaping

Model description:

RMA2

- Reynolds form of Navier-Stokes equations for turbulent flows
- Manning or Chezy equations to calculate the bed and banks friction
- eddy viscosity coefficients to define characteristics of turbulence
- A two-dimensional depth-averaged hydrodynamic model
- using finite elements method

RMA2

- The forms of fluid mass and momentum conservation equations are:

$$h\frac{\partial v_x}{\partial t}+hv_x\frac{\partial v_x}{\partial x}+hv_y\frac{\partial v_x}{\partial y}-\frac{h}{\rho}\left[E_{xx}\frac{\partial^2 v_x}{\partial x^2}+E_{xy}\frac{\partial^2 v_x}{\partial y^2}\right]+gh\left[\frac{\partial a}{\partial x}+\frac{\partial h}{\partial x}\right]+$$

$$\frac{gv_x n^2}{\left(1.486h^{\frac{1}{6}}\right)^2}\left(v_x^2+v_y^2\right)^{\frac{1}{2}}-\cancel{\zeta v_a^2\cos\psi=2hv_y\omega\sin\Phi}=0$$

$$\frac{\partial h}{\partial t}+h\left(\frac{\partial v_x}{\partial x}+\frac{\partial v_y}{\partial y}\right)+v_x\frac{\partial h}{\partial x}+v_y\frac{\partial h}{\partial y}=0$$

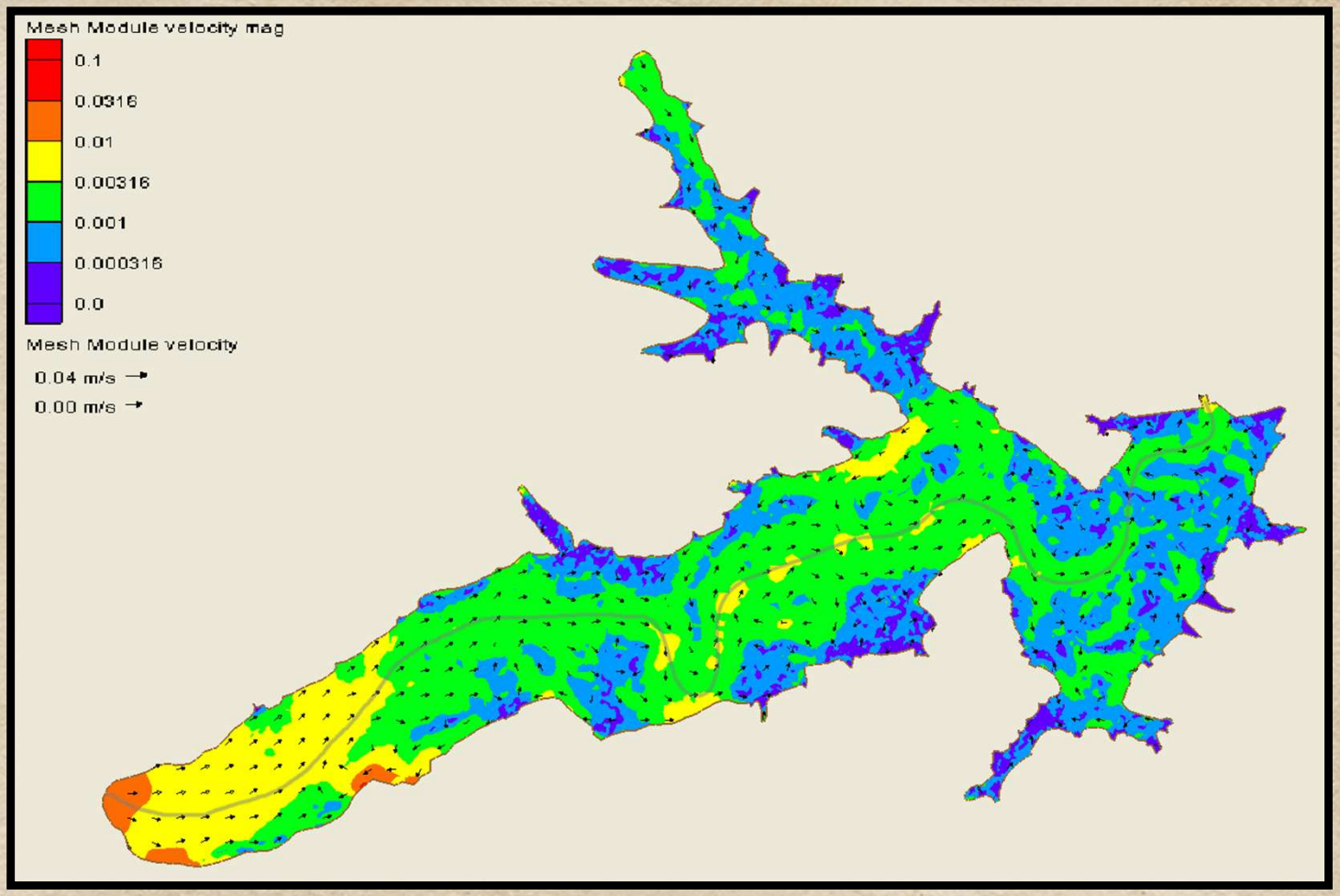
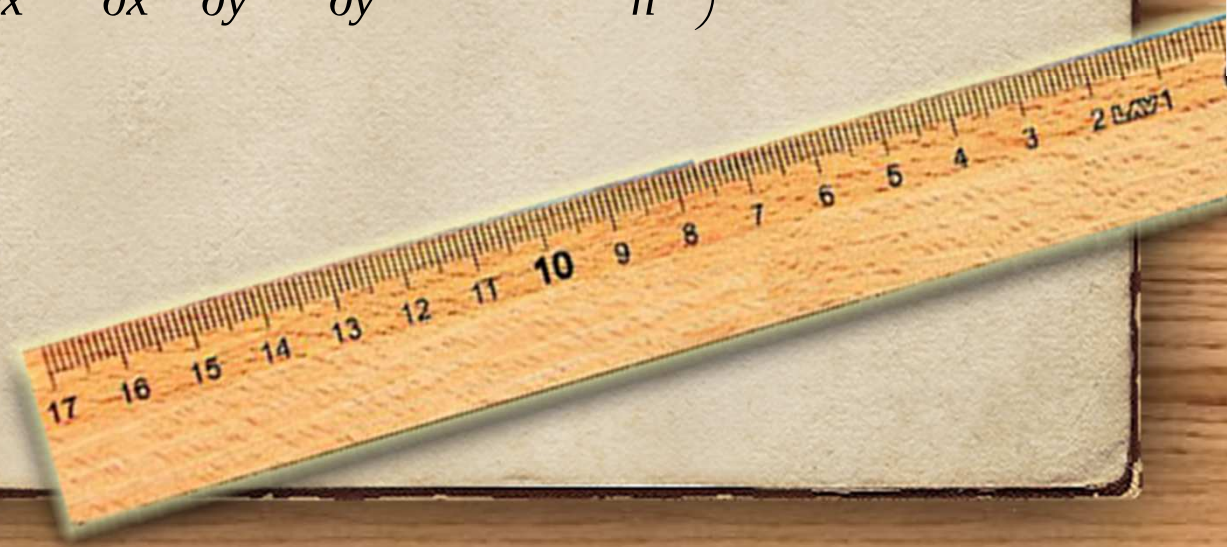


Fig.3. Velocity map for typical conditions with the main current line presented

RMA4

- model related to RMA2
- simulate the depth-averaged advection-diffusion processes
- estimation of propagation of any constituent dissolved in aquatic environment
- depth-averaged transport equation :

$$h\left(\frac{\partial c}{\partial t}+v_x\frac{\partial c}{\partial x}+v_y\frac{\partial c}{\partial y}-\frac{\partial}{\partial x}D_x\frac{\partial c}{\partial x}-\frac{\partial}{\partial y}D_y\frac{\partial c}{\partial y}-\sigma+kc+\frac{R(c)}{h}\right)=0$$



Methodology:

- two-dimensional mesh
- boundary conditions located on the tributaries and on the outflow
- lake working under normal conditions ($12m^3/s$ total discharge)
- static velocity field
- simulating three different scenarios:
    - Persistent inflow of organic pollution from Raba (1) and Wolnica (2);
    - 12-hour organic leakage near tributaries (3), (4) and (5);
    - 3-hours leakage of industrial waste from haven (6) and power station (7)

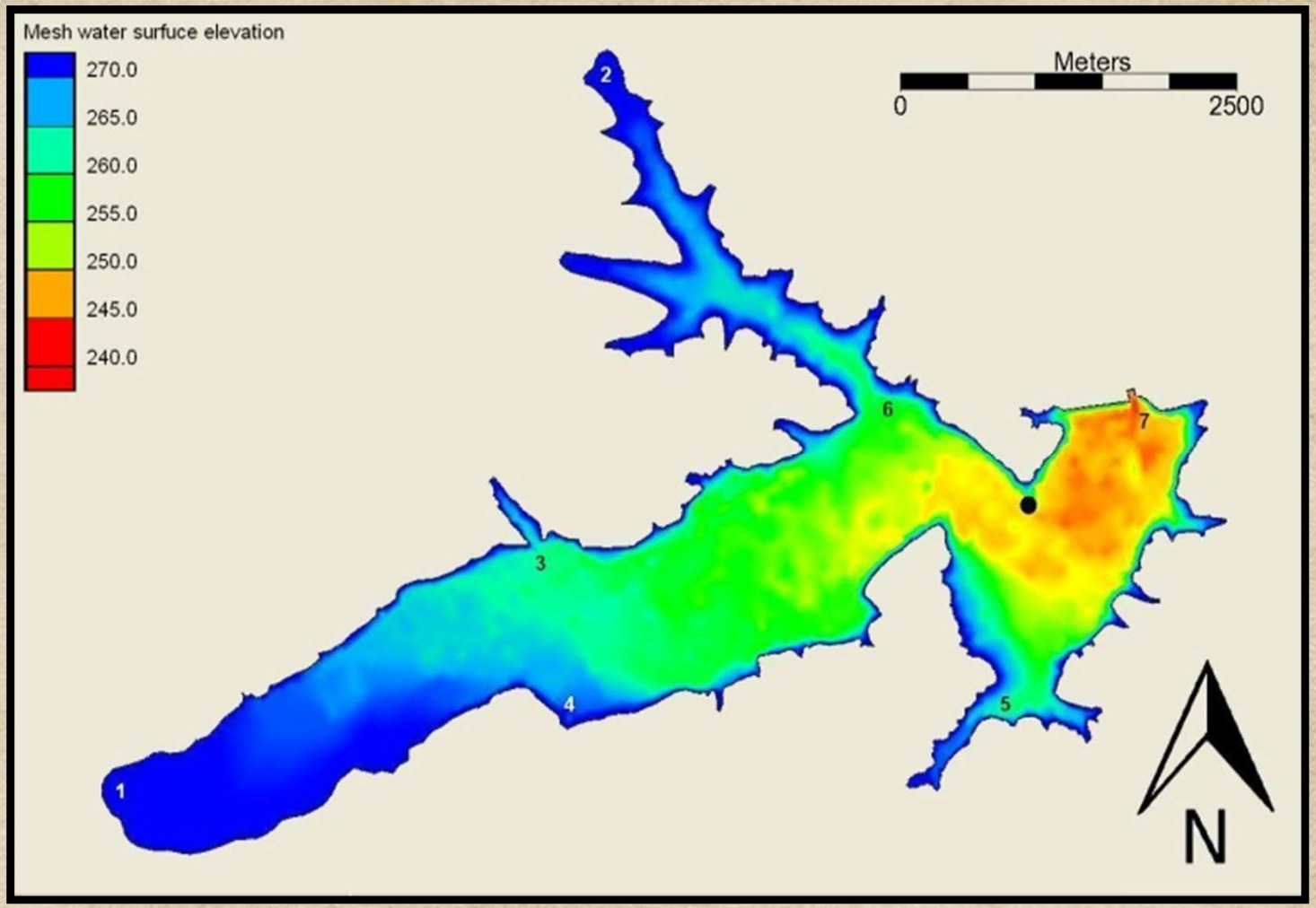
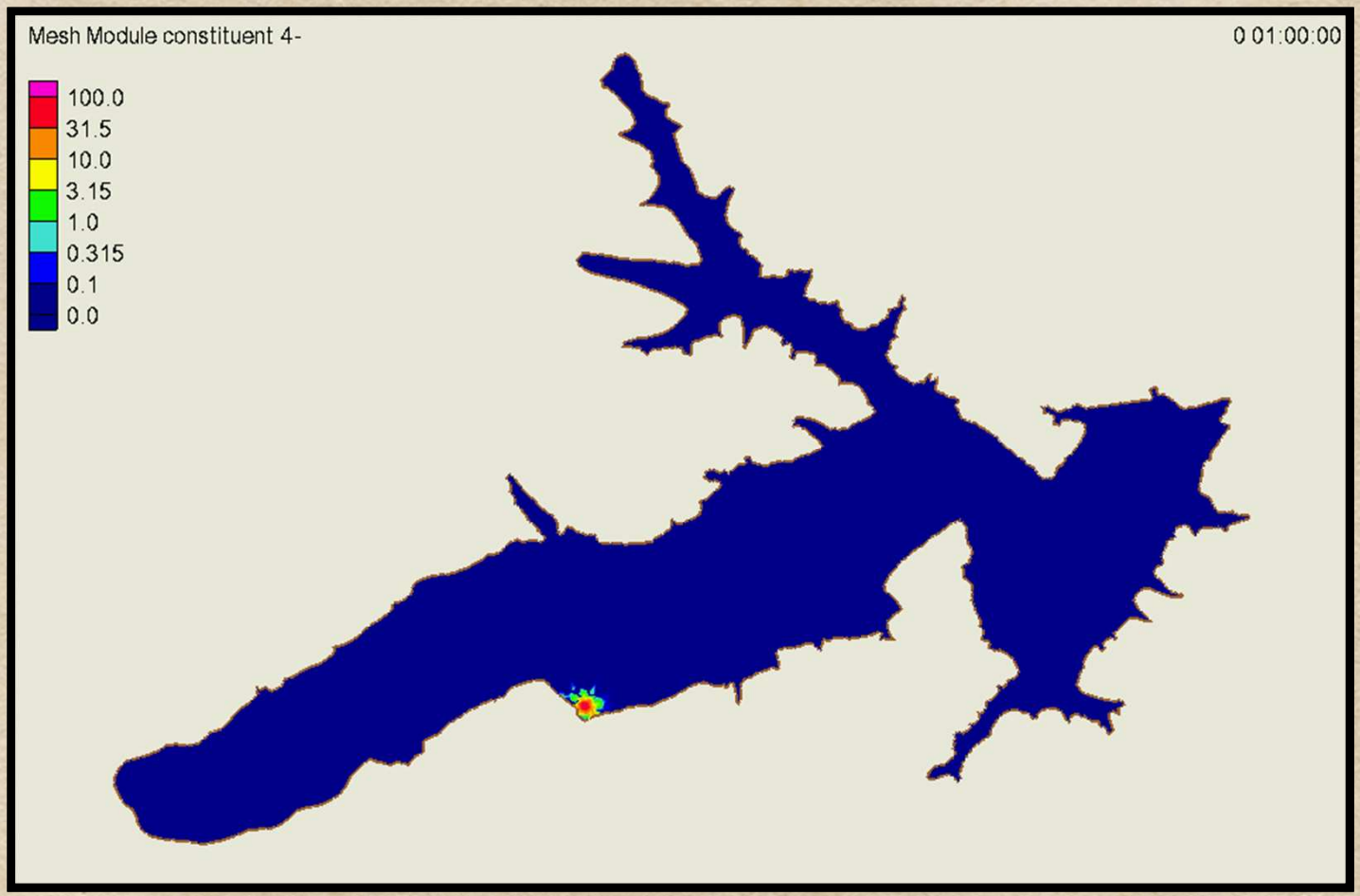
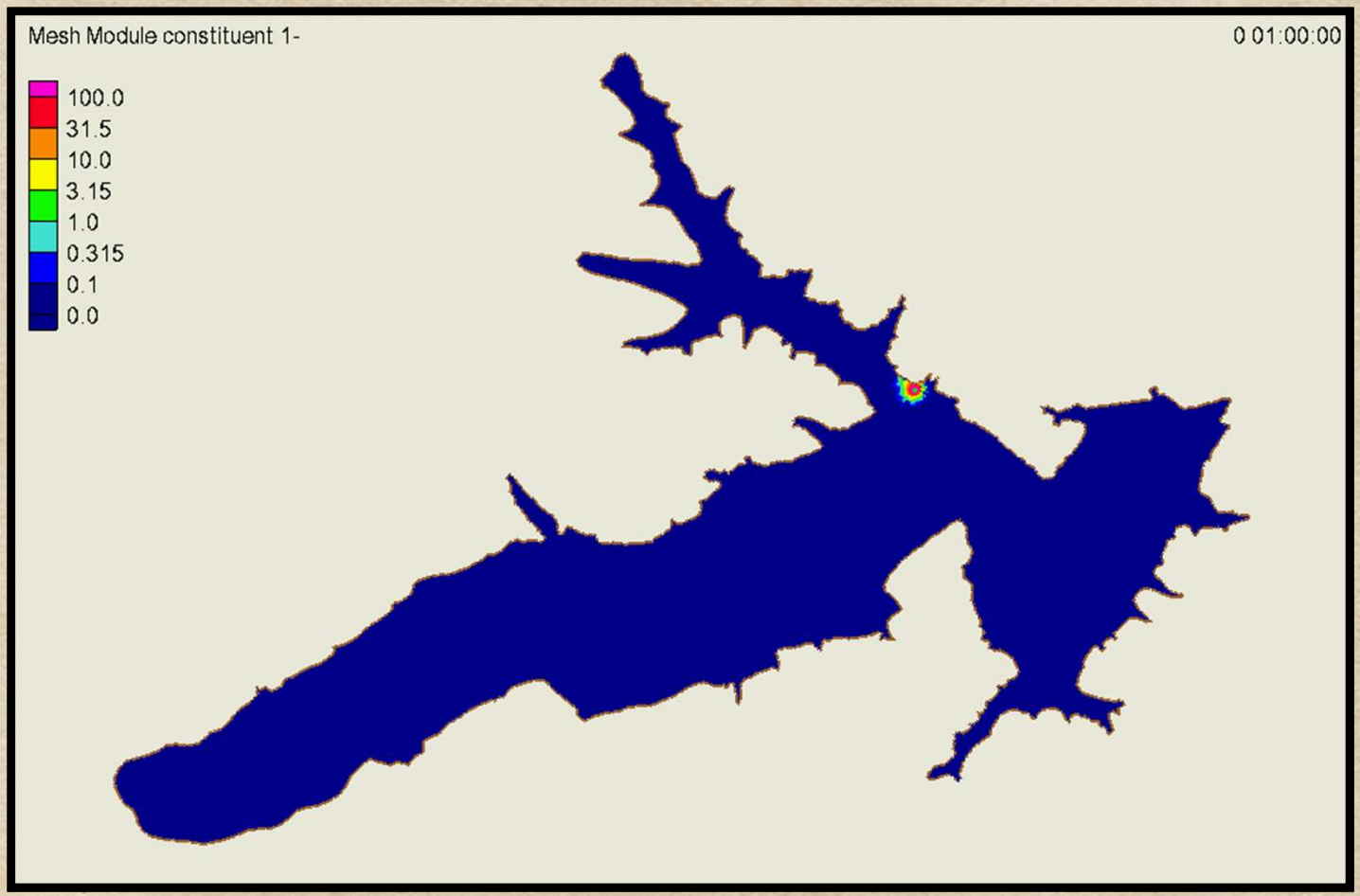


Fig.3. The bathymetry and shape of the Lake

Simulation for organic constituent came from location 4



Simulation for mineral constituent came from haven



Summary and conclusion:

- ✓ RMA2/RMA4 is a model suitable to calculate propagation of dissolved contamination
- ✓ No contraindication of using following model in retention mountain reservoir (stable results)
- ✓ Calibration based on observational data is required

Sources of graphic elements:

http://pl.wikipedia.org/wiki/Plik:Dobczyce_sluza_A.jpg
http://taurustrade.pl/components/com_virtuemart/shop_image/product/b65bff2bad9c409ec64d626f1bea3013.png
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Thank You for attention